Microsoft Research Short Course

COM+ Runtime Technology (Part Two)

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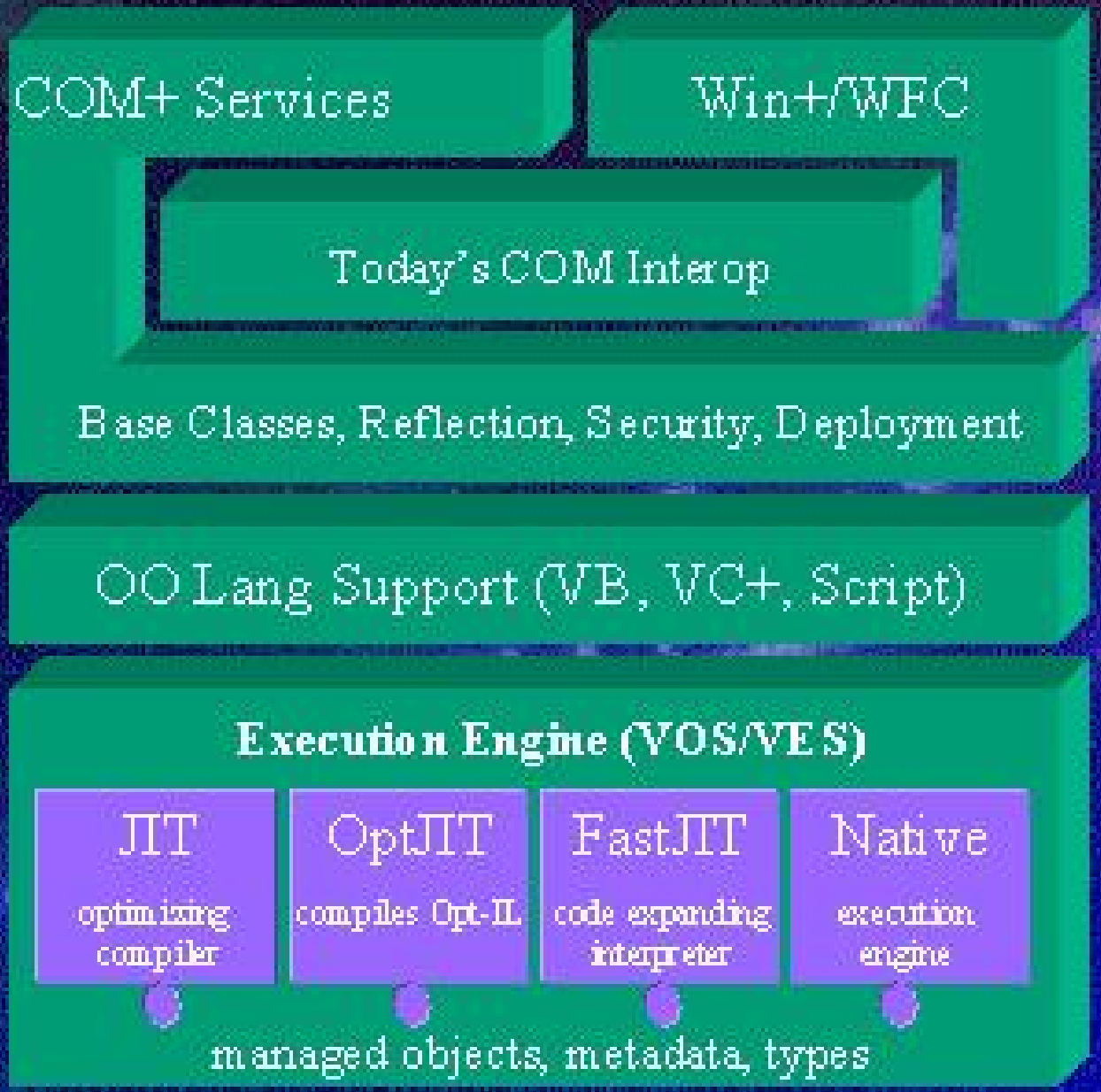
COM+ Runtime

COM+ Short Courses

- Last Week: "VOS level"
- Today: "Enterprise"
  - Garbage Collection
  - Assemblies
  - Contexts
  - Remoting
- Proposed: Security
- Proposed: What's wrong with the COM+ Runtime

Architectural Overview



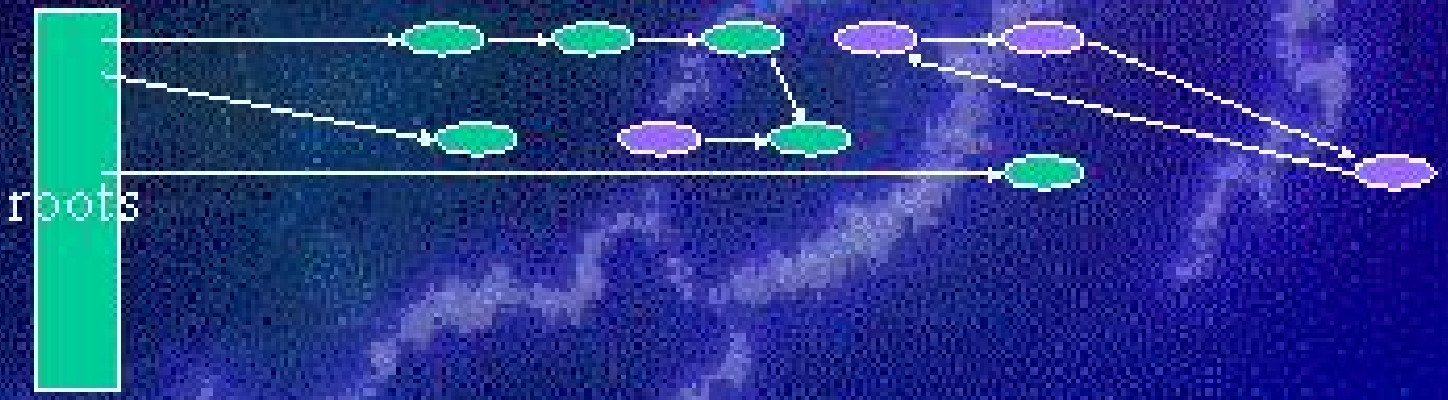
- Lowest level is Microsoft IL + objects
- Language support is built over execution and object model
- Some languages assume reflection, base classes
- COM classic interop assumes classes, reflection, deployment
- COM+ Services are combination of COM classic and runtime objects
- WFC and Win+ will leverage COM classic interop

Agenda

- Garbage Collection
- Contexts
- Assemblies
- Remoting

Garbage Collection

- Lifetime of object based on reachability
- Starts from roots: Stack and globals.



FOR MORE INFO...

Garbage Collection: Richard Jones and Rafael Lins (Wiley)

Uniprocessor Garbage Collection Techniques: Paul Wilson
http://www.cs.utexas.edu/users/oops/papers.html

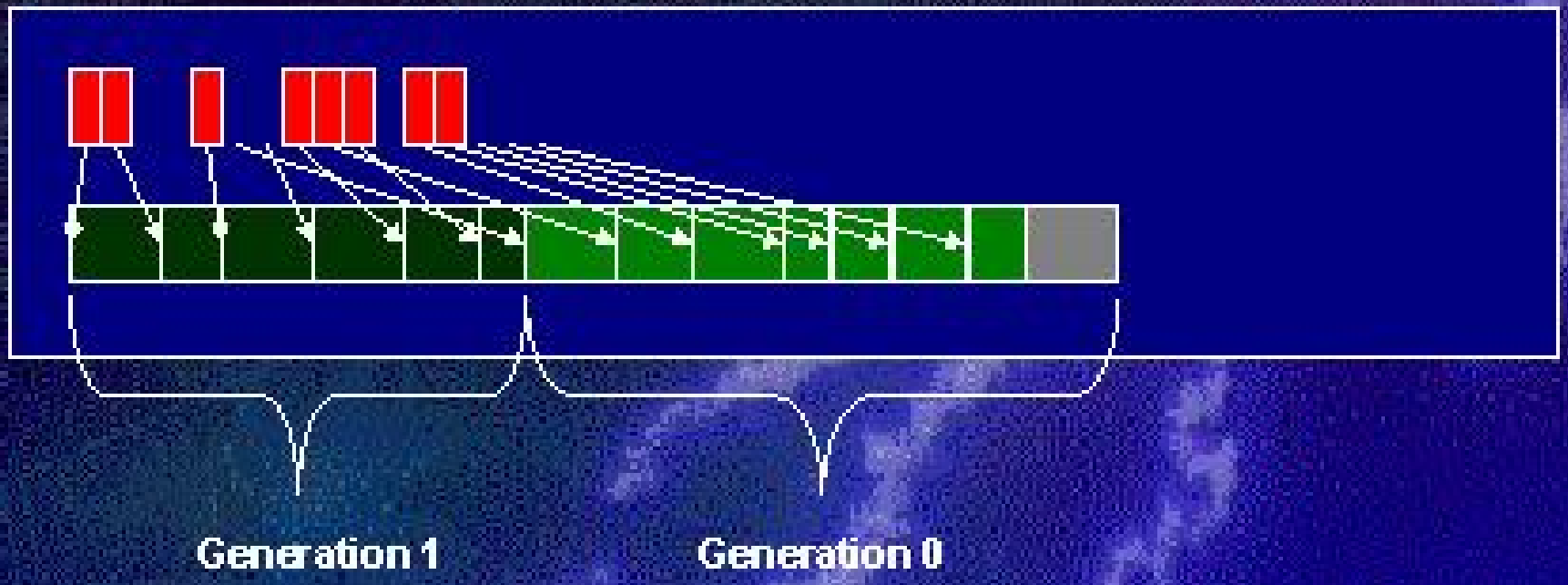
COM+ EE Collector

- Mark and Compact Collector
- Generations with write barrier
- Keeps objects ordered
- Low fragmentation, low memory overhead
- Cache conscious
- No conservative GC support
- Pinning

High Performance Allocator

- Automatic Memory Management
  - State of the Art Garbage Collected Core
    - Generational compacting
    - Low Fragmentation / Memory Usage
  - Transient Activity / Transaction Heaps
- Performance Results/Expectations (P200)
  - 1ms Max Pause for Gen 0
  - < 10ms Max Pause (w/ Writewatch OS Support)
  - Allocate/Lifetime/Free Competitive to Heap Alloc
  - Collection as Intrusive as Page Fault
- Allocation Contexts
  - No locks
  - No cache snooping

Generational GC



New Heap Begins with New Generation

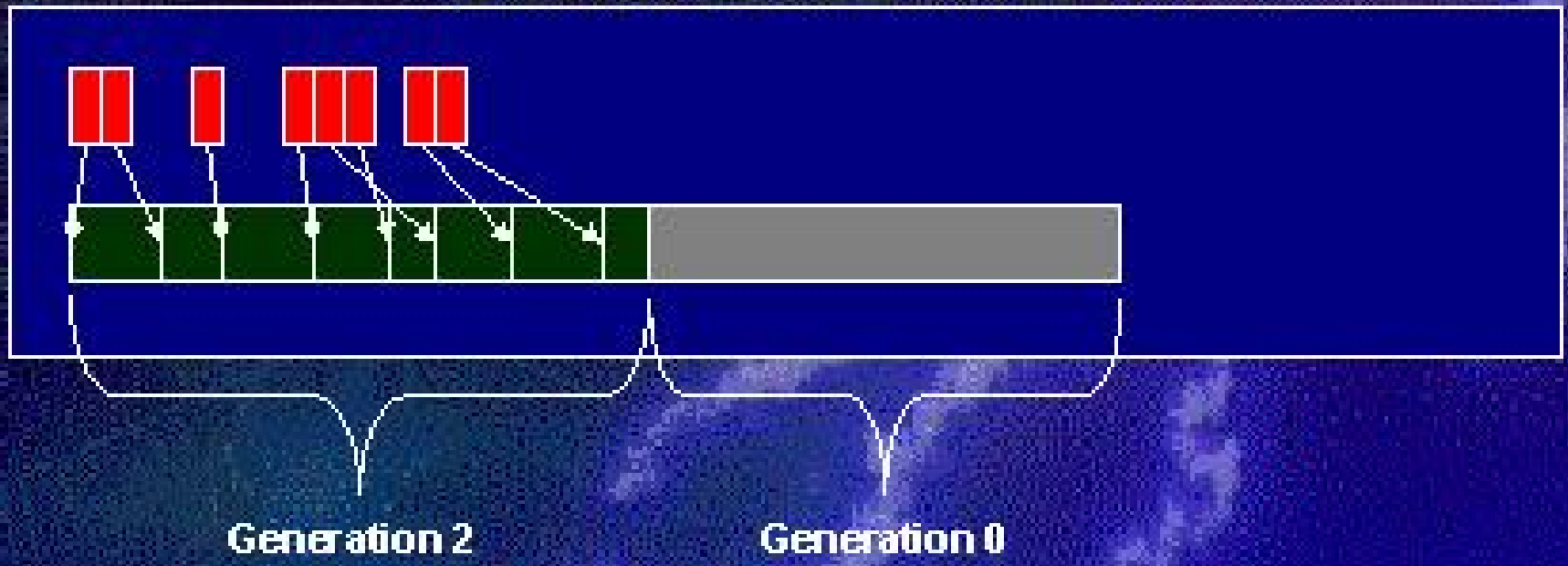
Accessible References Keep Objects Alive

Preserves / Compacts Referenced Objects

Objects Left Merge with Older Generation

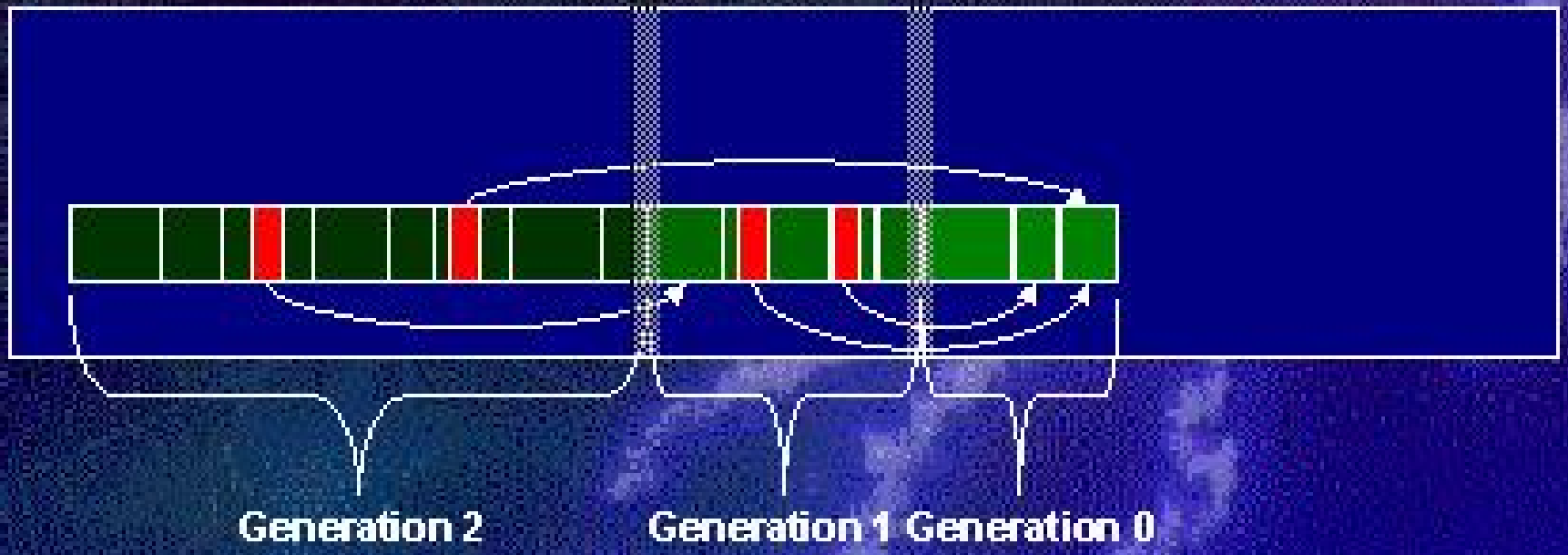
New Allocations Rebuild New Generation

Generational GC



- Generations Dynamically Tuned
  - CPU Cache Size
  - Acceptable Fragmentation
- Older Generations are Larger / More Stable
  - Require Collection Less Often
  - Are More Expensive to Collect
  - Can Have References to Newer Objects

Write Barrier Support



- Cross Generation (old->new) Refs Tracked
- Great Performance / Working Set Benefits
- OS Cooperation Improves Both (WriteWatch)
  - Enables Concurrency / Maximum Pause < 10ms
  - Ability to Minimize Working Set Impact

Dynamic Tuning

- Decides when and how to GC
- Gen 0 should fit in L2 cache
- Constant growth model
- Estimates when is a good time to GC
- Chooses sweep or compact based on fragmentation limits, set for each generation

We win because:

- Ephemeral design
- Cache conscious approach
  - Gen 0 fits in L2
  - Only Mark phase is “random walk”
- Respects object placement
- Low memory overhead

GC Scaling Performance

```
class Small
{ int i, j;
  public Small(int _i, int _j)
  { super(); i = _i; j = _j; }
};

for (int iter = 1; iter <= 10*1000*1000; iter++)
{ Small s = new Small(42, 69);
  if  (s.i != 42 || s.j != 69) throw . . .
}
```

1 thread, booted as uniprocessor: 44 cycles/iteration

1 thread, multiprocessor: 50

2 threads, multiprocessor: 66

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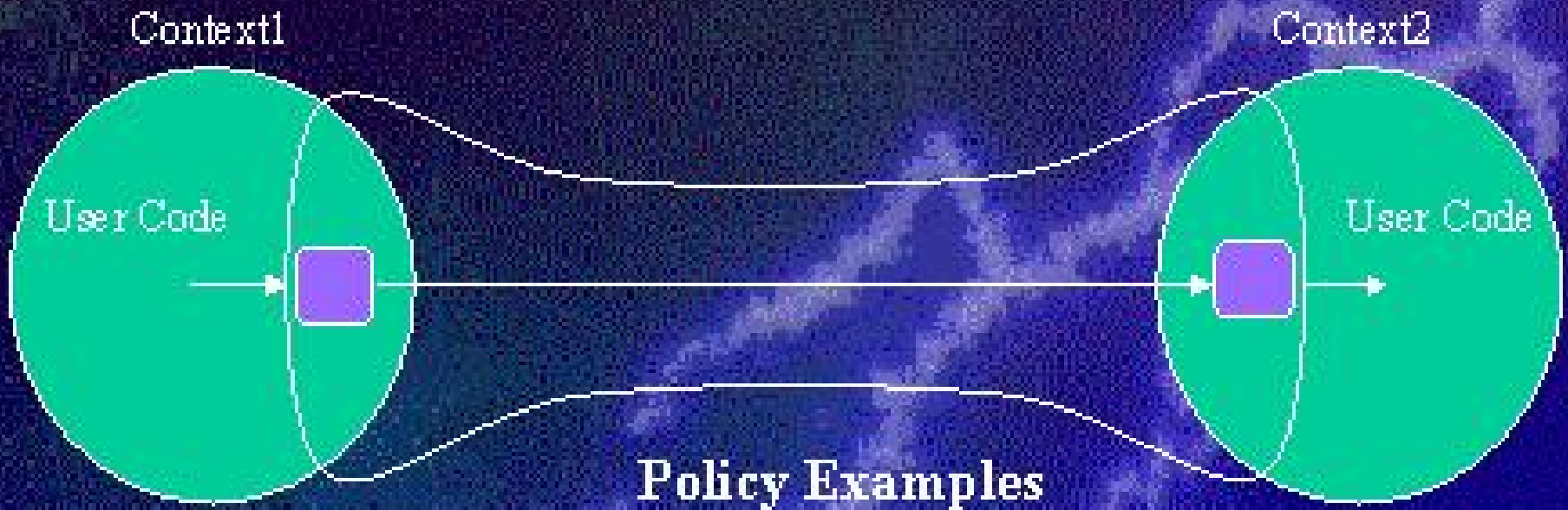
Contexts

- Generalized support for object isolation
- Processes are partitioned into contexts
- Each thread has a "current context"
- Context represented by an object
- Policies control inter-context references, based on:
  - Full process stack at call site
  - Method and parameters (or field)
  - Destination object and class

Contexts



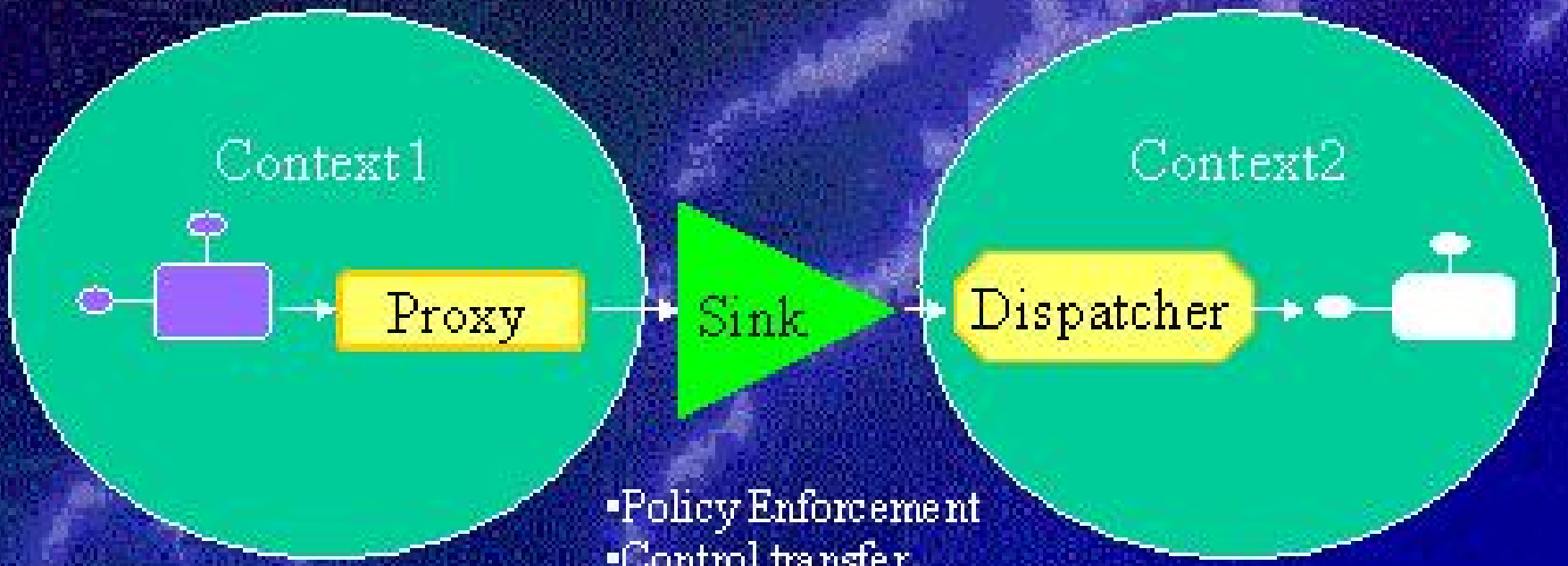
Policy Examples

- Security Checks
- Type Identity
- Synchronization
- Transaction boundary

Examples of Contexts

- Application Domain
  - Class Identity not preserved
- Cross Process
  - Copy In/Copy Out, not sharing
- Cross Machine
  - Like Cross Process, but copying may be slow and error prone
- Agile Classes
  - Think of them as in all contexts within a given process, simultaneously

Cross Context Communication



- Policy Enforcement
- Control transfer
- Data transfer

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The Deployment Problem

- Fragile
  - I installed my new database modeling package -- now all apps that use OLE DB are broken and no one has a clue what's wrong.
- Complex
  - Why do I have to understand registry goo in order to figure out if my application is correctly installed?
- Opaque
  - What will break if I delete this directory?
  - Do I have everything I need to run this app off line?
  - What do I need to move the app to my new machine?
  - How did *this* get here?

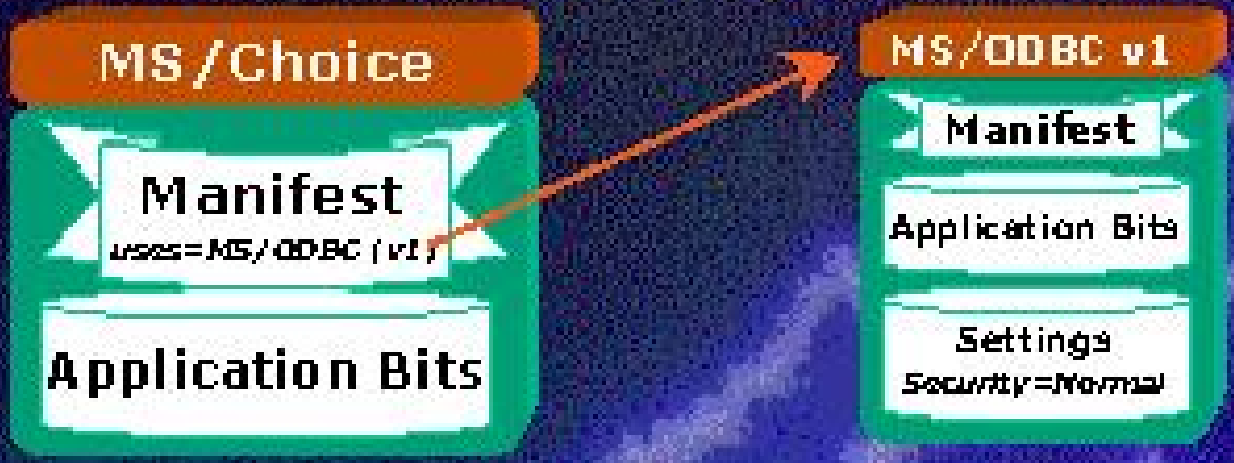
The Solution

- Application Isolation
  - New applications don't break old applications when new versions of components are installed.
  - Configuration rules for an application affect behavior of all components acting on its behalf.
  - Sharing is explicit.
- Simple Registration Model
  - No registry dependency.
  - Self-describing applications.
- Runtime Infrastructure
  - An integrated set of services to define, package, advertise, manage, and monitor component-based applications.

Building Block: Assemblies

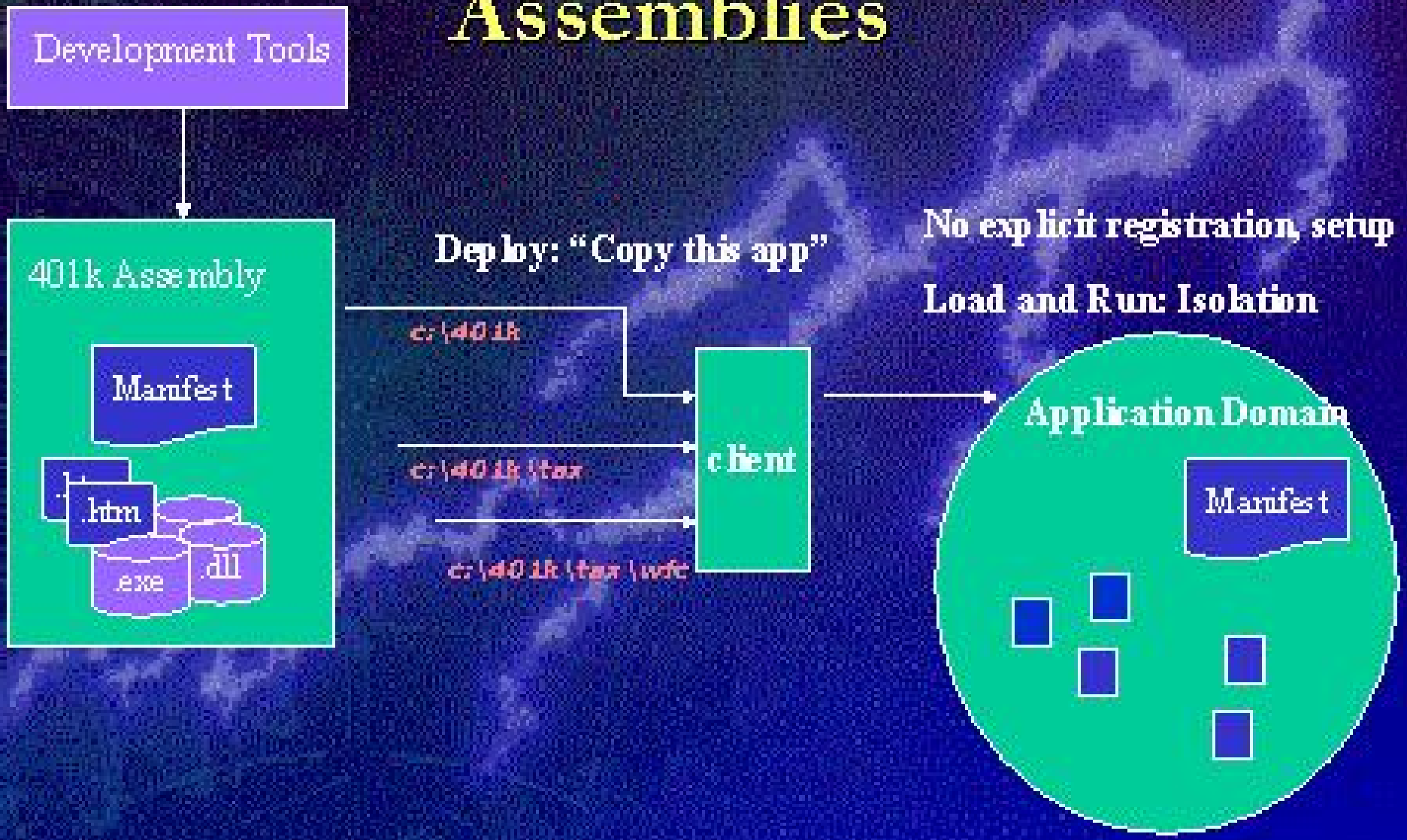
- A collection of resources (classes, html files, etc ..) that are built to work together: a "logical" dll
- The fundamental unit of deployment, versioning and reuse
- Private mapping of logical resource to physical packaging
- *Manifests* describe:
  - explicit list of public resources
  - explicit dependencies on other assemblies
- Examples: MDAC, Word, a customer Banking application, WFC

Manifests



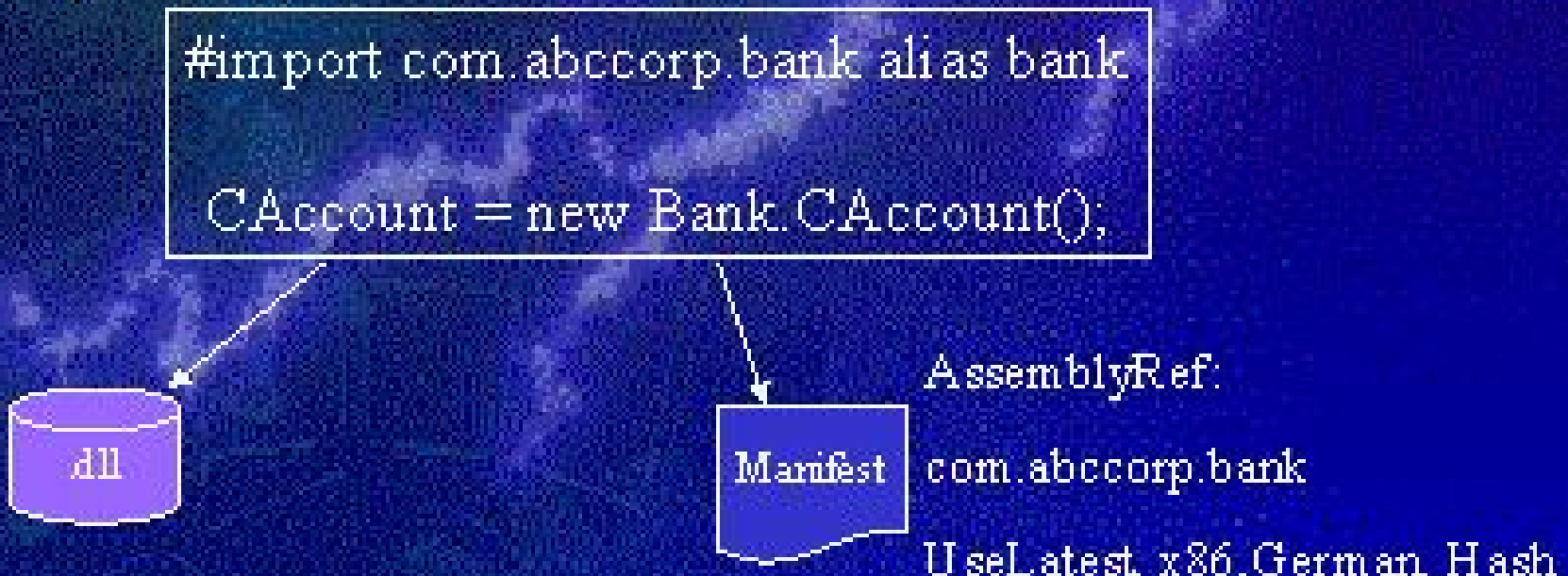
- Manifest defines policy and assembly structure
  - Locating referenced assemblies
  - Expressing version binding rules
  - Additional configuration info
- Authored or emitted by tool, edited by admin
  - Can live inside .dll as extension of component metadata
  - Can be stand-alone file as a packaging decision
  - Admin can configure, but original retained as "safe mode"
- Not required for simple deployment

Building and Deploying Assemblies



Assemblies and Development

- Always author in an assembly
- Assembly establishes development-time namespace
- Extend the namespace by importing other assemblies



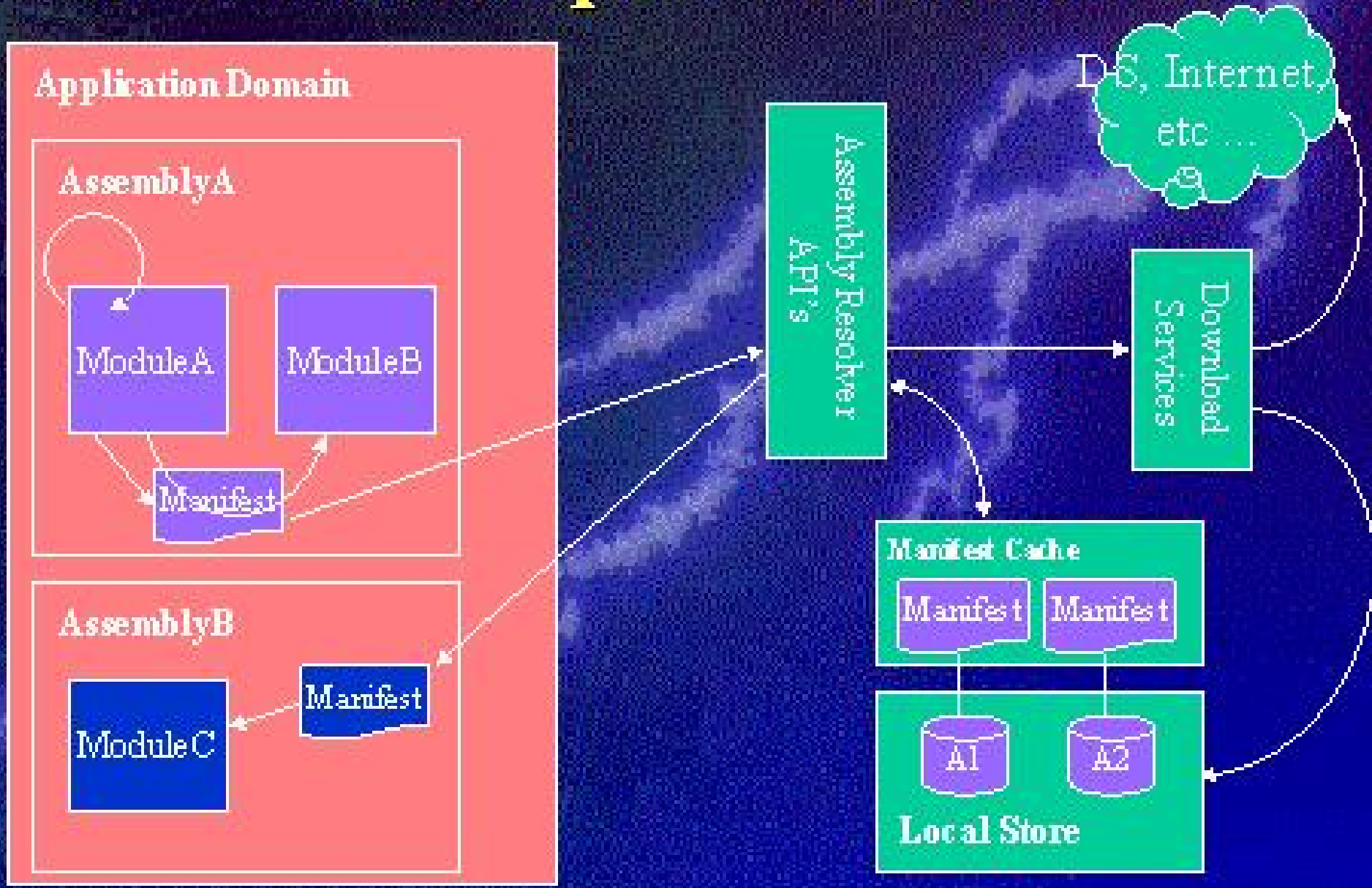
Assemblies and Deployment

- Deployment can be as simple as xcopy
  - "Run From Source"
  - Manifest not required
- Integrated with:
  - MSI
  - ZAW
  - SMS, etc ...
- On Demand, Zero Impact Installation

Assemblies at Runtime: Isolation

- Isolation of code, data, settings, …
- Essential for solving DLL Hell
- Assemblies establish namespace for resolution
- Manifest governs how references are resolved
- Side by Side
  - Multiple versions of an assembly running in the same process
- Application Domains

Runtime Request Resolution



Versioning

- Versions expressed at the Assembly level - not the class level
- Editable by administrators
  - Original manifest immutable, changing policy implies creating a "new manifest"
  - Use Latest
  - Use specific version
  - Use the version I was built with
- Safe Mode
  - Hashes recorded for every reference
  - "Run Once, Run Forever"

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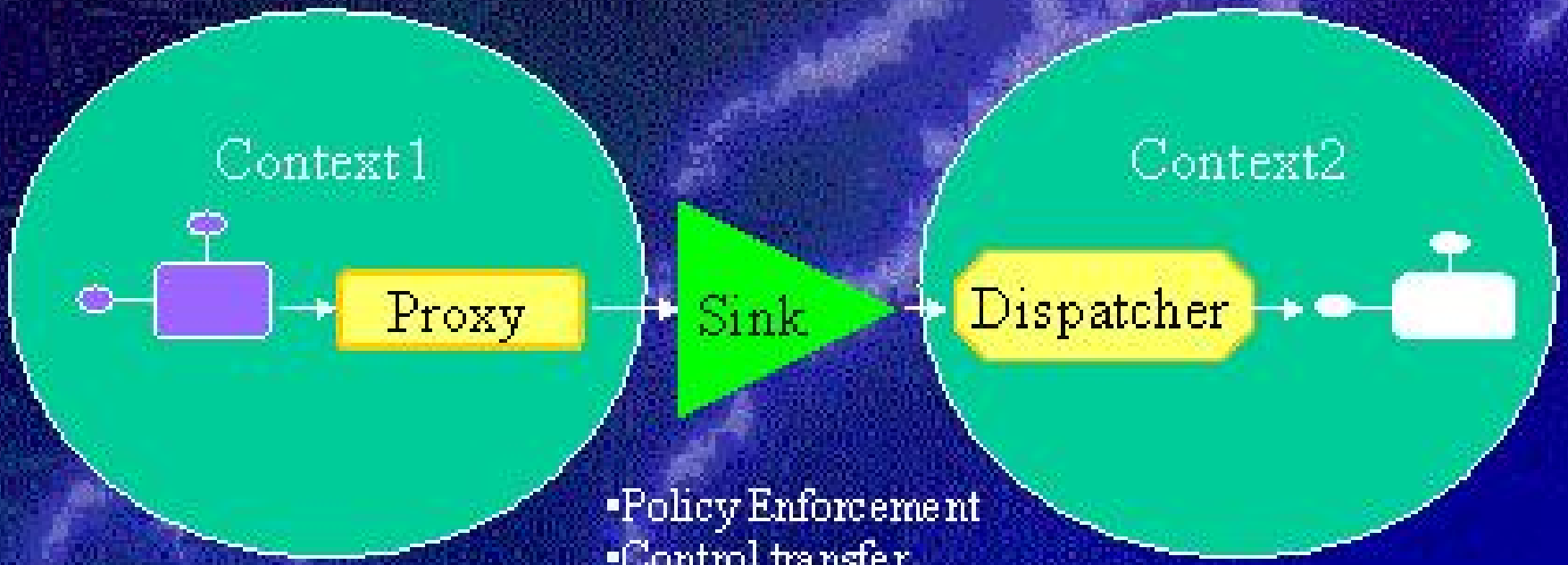
Remoting Based on Contexts



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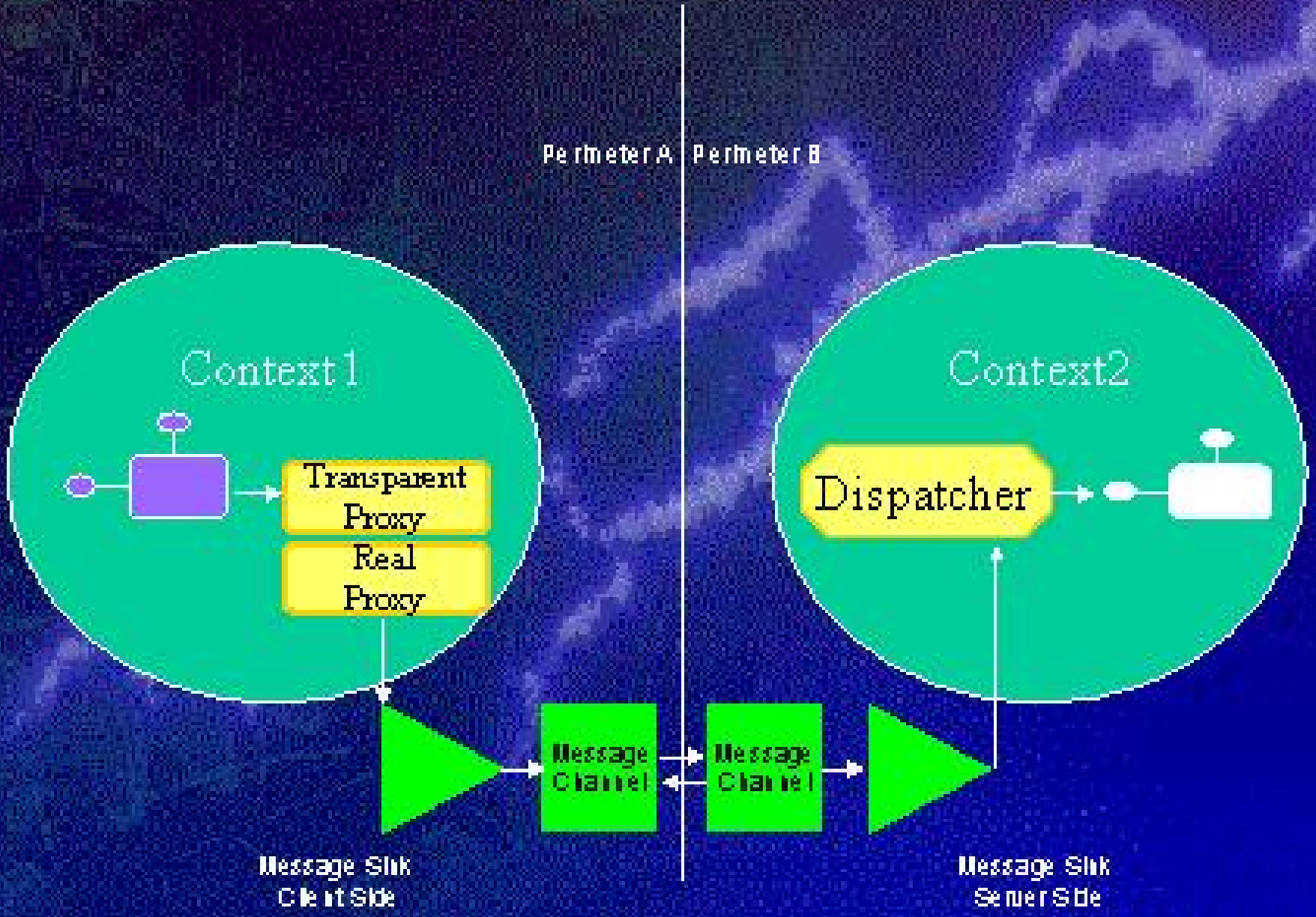

Message Sinks

- Support for request-response, one-way messages, multicast events
- Composable for complex semantics
  - sequences represent protocol/driver layers
  - fan-out, fan-in and pull (queue/DB based)
- Optionally Incorporate Key Properties
  - object identity
  - [security] identity information
- Optional Reply sink on Send

From Interfaces to Objects

- COM: interfaces and basic data types
- Smalltalk, VC, Java, COOL: “Objects”
  - Interfaces
  - Classes
    - Methods
    - Fields
    - Statics

Remoting

- Runtime generates proxies and stubs automagically
- Features
  - Standard set of remotable types (CLS)
  - Metadata allows us to remote self describing types
  - Objects passed by Value or by Reference

Properties and Events

- Properties
  - As in COM
  - Users think they are fields
  - Tools implement them with methods
- Events
  - One-way communication
  - Loosely coupled
  - “Plumbing” with “register” and “fire”
  - Events pass data when they fire, captured as a signature on the event

Remoting Programming Model

Subject to change without notice!

- **Programmers should assume all classes support remote instances**
- **The current object is local, including all inherited state (*this* and *super**)**
  - All fields are in current context
- **Field access to remote objects is remoted**
- **Static access to remote classes (fields or methods) generates a JIT time exception**
- **Recall that instances of agile classes are available in all contexts**

Remoting Programming Model (A Thought Experiment)

```
Class Complex
{ double R, Theta;
   . . .
};
Complex Matrix[] =
    new (Complex[10000, 10000],
         RemoteHost("supercomputer.org"));
Initialize(Matrix);
Matrix.Invert();
Text.Out.WriteLine(Matrix[0].Theta);
```

Cross Process Remoting

- LPC Sink - Uses channel to send and receive messages
- LPC Manager
  - Initializes cross process remoting
  - Creates and deletes channels
- LPC Channel
  - Manages LPC Ports
  - Managed memory sections
  - Send and Receive Messages

Cross Machine Remoting

- Simple Object Access Protocol (SOAP)
- SOAP *is* COM+ remoting over HTTP.
- Outreach: Simple enough that SOAP endpoints can easily be created using a wide variety of technologies, including scripts
  - Perl, Python, ???, .. (ad hoc)

SOAP Goals

Interaction across the web with these goals:

- Work well with existing Web infrastructure
- Work better with future Web infrastructure
- Introduce no new security holes
- Support reach requirements of partners
- Lower barriers to adopting COM+ runtime
  - enable interop solutions in heterogeneous environments
  - including classic COM

SOAP Method Invocation

- Objects represented by URL
  - Well known endpoints: no ORB needed
  - Dynamically create instances
- Object invocation over HTTP via M-POST, POST, and GET
- Marshalling using XML for interoperability
  - optional interface
  - Method
  - Parameters

Open Issues

- Activation
- Programming Model
- Distributed Security
- Concurrent GC
- Distributed GC